5. Joint land and water management strategy to mitigate drought risk

5.1. Identification of water retention areas on the Dong-ér catchment using GIS

György Sipos, Tamás Právecz

Introduction

Water shortage and the decreasing groundwater levels experienced in the last decades are increasingly endanger the ecosystems and economic activities in the Danube-Tisza Interfluve (Rakonczai 2011, Kovács 2007, Ladányi et al. 2011a). This trend seems irreversible due to the climate change and the increasing water demand, thus every action serving the water supply of the region are and will be essential (NVS 2013). One of the most evident ways of water supply is the more effective retention of precipitation and inland excess waters. In the Hungarian practice, the two main methods of water retention are the retention of water in drainage canals and in local depressions or in former lakebeds.

These practices can be analysed from the viewpoint of the type of storage area and also the objective of the storage. The most frequent objectives of storage are irrigation, nature protection or fishery. On lowland catchments permanent water storage can hardly be achieved due to the low surface runoff, however the surplus water occurring in more humid or waterlogging periods can have important part in groundwater recharge, thus retaining local water resources instead of drainage have to be focused during development of complex future strategies (Somlyódi 2011). Supporting these aims, the areas potentially suitable for water retention were analysed and identified using GIS on the catchment of the Dong-ér major canal, the main waterflow of southern part of the Sandland region. Based on topographic, hydrographic, soil and land cover data, the areas, which can be suitable for longer water storage and also for ground water recharge with smaller land use conflicts, were identified. In this phase of the research, developing exact recommendations was not aimed, because this requires more detailed analysis of the potential areas.

Study area

The catchment area of Dong-ér is 830km^2; the length of its heavily modified water body is 81 km. The present function of the canal is inland excess water drainage (VKKI 2010). The stream density on the catchment is low, only 0.5 km/km^2. Recorded discharge values are not available to describe its highly fluctuating discharge, however, on the basis of estimations the runoff in the hydrological system can reach the 10-15 m^3/s in periods of inland excess water inundations (Dövényi 2010). In humid years groundwater can appear in the deflation hollows, forming temporarily inundated areas. Previously alkaline lakes were dominant in the larger deflation depressions; however many of them have already been dried out totally. The western part of the catchment is located on the Bugac sandland region, the southern part is located on the Dorozsma-majsai sandland region, while the northern part is belong to the Kiskunság löszös hát (Kiskunság loess region). The Bugac sandland is an eolian formed alluvial plain fragmented by blown-out depressions, residual ridges and other wide interdunal depressions often covered by water or peat of northwest-southeast direction (Pécsi 1967). The Dorozsma-majsai sandland region is mainly slightly undulating area; however undrained depressions arranged into northwest-southeast direction are typical also in this region. The Kiskunság loess region is an alluvial plain covered by loess and sand with temporary lakes and marshes (Pécsi Dunai Alföld). The dominant soil type (fitting to the Sandland character) is the blown sand, covering 51 % or the catchment and humic sand (covering 19 %), other soil types are alluvial meadow soil (10 %), chernozem type sandy soil (6%) and chernozem or meadow soils on the remaining areas. The catchment is one of the warmest and driest areas, the annual precipitation sum is 520-580 mm, but in extreme years much less precipitation can occur. Therefore the drought hazard is high in the area. The depth of the groundwater level is 4-6 m and the groundwater recharge is important task because of the decreasing groundwater table in the Danube-Tisza Interfluve (Rakonczai 2011).

Methods and data sources

For identification of water retention areas topography, hydrography, soil and land cover data were overlaid by ArcGIS 10.1 software. The basis of the analysis was the 5-meter digital elevation model (DEM), which was used for calculating slope map to define the suitable local depressions considering engineering aspects. An important aspect of the assessment was the distance from canals, inner areas of the settlements and from linear infrastructure using canal database of ATI-VIZIG and settlement and road and railway network data of DTA 50 database.

Beside engineering aspects, the soil condition is also important factor in defining suitable areas, since it basically determines the potential objective of the water retention (surface storage or groundwater recharge). For assessing soil conditions water holding capacity data of 1:100 000 scale Agrotopographical map was used.

Finally, the selected areas were re-evaluated to minimize the potential land use conflicts. For this evaluation, 1:100 000 scale Corine Land Cover (CLC) database was applied. The CLC is hierarchical classification system, having five major categories (Artificial surfaces, Agricultural areas, Forest and semi natural areas, Wetlands and Water bodies) and each have several subcategories. On the analysed catchment, 17 land cover types were identified. That was also considered, if the potentially suitable areas are Natura 2000 sites.

Engineering aspects of the identification of water retention areas

Three criteria were defined when allocating areas suitable for water retention. 1) The slope of the surface does not exceed 1 m/km, thus water retention can be realized on larger areas with minor interventions. 2) The distance of the potential areas from canals or waterflows does not exceed 1 km to make smoother the integration of the new reservoirs into the regional water management. 3) The selected areas should be minimum 100 m distance from linear infrastructure (roads, railways) and 1 km from settlement inner areas to decrease the necessity of further engineering interventions.

The overlapping area of the selections based on the three criteria was allocated. As a result of the selection, numerous (a few thousand) small patches were also selected with only an area of few hundred m², but during the further assessments only the areas larger than 1 ha were counted (Fig. 5.1 on page 161).

Finally, considering all of the defined criteria 2038 separate areas could be suitable for water storage. The average area of these patches was 4.34 ha, however the number of suitable patches are exponentially decreasing with the increase of the area, thus the area of 395 patches increased the 5 ha and only 10 patches were larger than 50 ha. The area of the largest potential storage site was 197 ha. On the basis of the assessment, 10.6 % of the catchment (8850 ha) could be suitable for water retention from topographical and hydrographical point of view. Beside these criteria several other aspects were also assessed, which are presented in the followings.

Analysis of the suitability of surface storage and groundwater recharge

During the analysis of engineering criteria soil properties were not assessed. The potential storage sites were categorized on the bases of the following soil properties: 1) soils having weak or extreme weak infiltration capacity (clayey soils), these can be suitable only for surface storage, for ecological water retention; 2) soils having high or extreme high infiltration capacity (sandy soils), which can be suitable also for groundwater recharge.

For selecting areas having the first type soil property, the 6th and 7th categories of soil water household factor defined by Agrotopographical map were used, while to select areas having the second type soil property, the 1st and 2nd categories were used. From the selected areas, the areas larger than 1 ha were allocated (Fig. 5.2 on page 162).

As a result of the evaluation, 707 and 1359 patches were defined as suitable for surface storage and for groundwater recharge, respectively (Fig. 5.3 on page 164), meaning 3.6 % (3000 ha) and 6.8 % (5680 ha) of the catchment. Consequently, the areas suitable also for groundwater recharge have almost double extent than the areas suitable for surface storage. The number of potential sites is significantly decreasing with the increase of the area in case of both soil categories. Where the soils having weak or extreme weak infiltration capacity, the number of sites larger than 5 ha was 127 (17.8 %) and the ones larger than 50 ha was only 4. Where the soils having high or extreme high infiltration capacity, the number of sites larger than 5 ha was 268 (19.7 %) and the ones larger than 50 ha was 6. Because of the type of data distribution, the average and maximum area are similar in the results of the different selection criteria.

Analysis of land use conflicts

Although the topography, hydrography and soil condition basically define, which areas areas the suitable for water retention, one of the most important limiting factors in final selection of the sites are the land use type and the ownership structure. To minimise land use conflicts, those areas were identified where the temporary inundation could cause only minor cultivation changes. The following criteria were set up to achieve this aim: land use type should be pasture (CLC 231), natural grasslands (CLC321), transitional woodland-shrub (CLC 324) or inland marshes (CLC 411); moreover that was also considered, if the selected areas are Natura 2000 sites. The latter condition can help decision-making.

From the selected areas, only the areas larger than 1 ha were evaluated. Based on this evaluation, 557 potential sites can be allocated on soils having weak or extreme weak infiltration capacity and 61.4 % of these sites are also Natura 2000 sites. In case of non-protected areas, the proportion of large patches is quite low, maximum patch area is 28 ha and the number of patches larger than 5 ha was only 51. While in case of Natura 2000 sites the maximum patch area was 28 ha and the number of patches larger than 5 ha was 215, however only the area of 2 patches exceeded the 50 ha. The summarised area of potential surface storage sites, which can be constructed with considering the aim of minimum land use conflicts, is 1850 ha, that means 2.2 % of the catchment (Fig. 5.3 on page 164).

Major proportion (56,3 %) of the 822 potential storage sites, where the soils having high or extreme high infiltration capacity was part of the Natura 2000 network (Fig. 5.4 on page 165). On Natura 2000 sites, 92 of the identified patches were larger than 5 ha, 4 patches were larger than 50 ha and the maximum patch size was 146 ha. The summarised area of potential groundwater recharge sites, which can be constructed with considering the aim of minimum land use conflicts, is 2180 ha, that means 2.6 % of the catchment.

Conclusions

Identification of areas, which are suitable for water retention (for surface storage or groundwater recharge) based on their position and land use, was carried out by GIS methods considering several aspects. The more detailed evaluation of the result maps are the aim of future research, however some general conclusion can be drawn also at this phase.

The selected areas, where soils are clayey or salt affected and having weak or extreme weak infiltration capacity are mainly temporary lakes already (e.g. the Büdös-szék between Baks and Pusztaszer, Harka lake northwest of Harkakötöny) (Fig. 5.3 on page 164).

It is aimed to evaluate in the further steps, that in case of these areas, to what extent can the water surface be increased in humid periods by the help of water controlling facilities in the drainage canals, considering topographical, soil and land use parameters. Another type of the identified areas is connecting to the interdunal depressions of northwest-southeast direction. (Fig. 5.3 on page 164). In case of these areas, the area of the local surface catchment and the connection with the groundwater have to be revealed and analysed if temporary inundated areas could be created.

The potential areas, where soils are sandy and having high or extreme high infiltration capacity, are located mainly on the higher elevated western part of the catchment, on the upstream section of waterflows and canals (Fig. 5.4 on page 165). Here, where the water input is low and the area of the local surface catchments is small, water retention and groundwater recharge cannot be achieved on large surfaces. The potential areas along the middle section of the Dong-ér seems be more suitable (Fig. 5.4 on page 165).

Finally, it should also be indicated, that the further analysis can only be complete by modelling the local water balance, since despite the appropriate morphology and soil conditions, an area cannot be suitable for water retention, if retainable water input is not generated on the surface and subsurface catchment of the area. Nevertheless, the areas identified by this research should be taken into consideration in planning potential interventions to minimise land use conflicts.

5.2 Possibilities of irrigation development and the effective use of water resources

Károly Fiala, Balázs Benyhe, Srđan Popov

Introduction

The availability of water, the partly renewable natural resource, is limited in the investigated catchment. Our task is to utilise the existing resources in an effective and sustainable way; and, if this is not enough, to supplement them. The main task and challenge of agricultural water management is to adapt to the changes in weather, especially to extreme weather conditions, which becomes increasingly important due to climate change. Besides the extremities in weather agricultural water management also has to adapt to the natural and artificial environment, to social and economic demands and their changes in time and space, and to technical and technological development

In agricultural production the abundance or lack of water causes increasing problems; the available water resource and water demand occurs usually not at the same place and time. This leads to the situation that when water is most needed, it is not available and vice versa. A further limiting factor is water quality, since its salt and contaminant concentration greatly influence its usability. Because of these problems water utilisation is only possible if water resources are effectively utilised and water shortage is supplemented from external sources when needed. Nowadays irrigation is a current topic, since the increasing frequency of extremities due to global climate change cause serious damages for agriculture, as well.

The situation of irrigation on the study area in Hungary

As an effect of changes in meteorological elements the intensity and frequency of droughts have risen, which also affects the productive capacity of agriculture. Since the spatial appearance of drought is significantly different, the caused damages are also unequally distributed. In the area under investigation, the Hungarian section of the right bank-side catchment of the Tisza (Fig. 5.5 on page 169), it causes great damages for both agriculture and ecology, due to the intensity and frequency of the phenomenon.

A main tool of the fight against loss of crop yield may be irrigation, which, due to several factors, fell back to one-third in the last 15 years. Without this tool no improvement can be expected in the fight against drought damage. In the Danube-Tisza Interfluve water use for irrigation has hardly any history in the past, despite the fact that the demand for irrigation is justified due to the unfavourable precipitation distribution. In the last 15 years the utilisation of irrigation water has changed hectically in the study area (Fig. 5.6a on page 170), due to the change of several factors. The transformation of plot structure (mainly becoming smaller) after the political system change was disadvantageous for unified irrigation and was strenghtened by the continuous degradation of the existing infrastructure. The previously characteristic irrigation based on surface water resources near the Tisza Valley is greatly decreased compared to the "peak period" of irrigation; the quantity of utilised water resources increased only in a few years.

There is a difference between the amount of authorized and used water amounts that can have more reasons. Water users having authority permission do not irrigate in all cases; it depends on available water supplies, the price of water, the cultivated crops, the existence of infrastructure and the farming skills etc. The fallback of irrigation farming is illustrated well by the temporal change of irrigated water amount. While at the end of the 90s and the beginning of the 2000s, 5-10 million m^3 were utilised on the area, this amount greatly decreased in the past years. This decrease is particularly serious, because during this period the amount of preciptiation did not really change, but temperature rose, just as the frequency of the number of drought years.

Irrigation from wells has a tradition on the catchment. It goes back to the 60s and 70s, when a great number of wells came into existence. These generally have a depth lower than 30-50 m, which can ensure the irrigation of smaller agricultural areas. Therefore, it is very important to examine this type of water use: the difference between surface, and subsurface water usage is illustrated by Fig.5.6b (page 170). Rising amount of water used for irrigation can be seen after the 90s up to 2009, when it suddenly started to decrease.

The need for irrigation development is a current topic in local communities and also in national organisations in the past decade, since as a result of climate change the frequency of serious droughts has definitely risen. The damaging effects of climate change can already be experienced: the intensity of agricultural production, the crop yields, furthermore profitability have decreased.

Due to its complex nature, irrigation is not only a mechanical, economic, geographic or social issue, but the coherence of all these viewpoints, therefore, it is necessary to develop complex systems. The viewpoints of agriculture, environmental protection, regional development and social approaches differ: the link is water, without which the sustainable development of the region cannot be realized, especially due to the negative effects of the greatest challenge: the climate change.

The conditions of irrigation farming

The most important basis of the irrigation development in the region is the existence of surface water, and its location within reasonable distance. The possibilities of dry farming could be a solution without sufficient water resources. However, this way plant cultivation may be limited, since, for example, irrigation water in our region is necessary for vegetable and fruit cultivation. Regarding water quality, crop type and soil puffer capacity are such determining factors that let only a few actions to the farmers.

Clear legal environment (land ownership, leasing), plot size and structure are necessary to create high-standard irrigation farming. The size of parcels became smaller after the period of intensive agriculture that is unfavourable in the point of irrigation, and their unifying would only be possible if the owners had an interest in it. Thus, creating optimal plot size is essential to be cost effective. Besides common sprinkling technologies in arable land farming, the size of irrigable area is 50-70 hectares using water reels, and its double, 100-140 hectares using a Linear type irrigation system under current costs-wages conditions. Another important factor is that the person carrying out irrigation farming should have ownership rights, which increases participation and appropriate operation; while leasing rights bear uncertainty, which decreases the willingness to invest.

The central, governmental participation is a high-priority task not only in development, but also in operation. Infrastructure for agricultural water management is rather costly; the cost of equipment and the lack of capital for investors slow down the development process. The government can play role in the simplification of permission process, the reduction of authority fees and VAT besides the development and operation. Irrigation development must be preceded by a support policy based on professional knowledge in the field. Another central role is professional help for irrigation farmers, to pass on knowledge and experience of operation, and to organise education. A regulation background is needed for the planned and reasonable operation of irrigation, which farmers must get acquainted with and accept. To deal with conflicts on the appropriate level, it is necessary to engage the parties involved when creating legislation connected to water usage.

For an appropriate standard of irrigation farming, the infrastructure of water management must meet occurring demands, thus the existence and condition of water controls basically define the short-, medium- and long-term development possibilities. Transferring the necessary irrigation water is impossible without existing infrastructure. The maintenance of the existing element is important, because the postponed works contribute to reduced water transport capacity of the system. Further developments should be planned to meet the simultaneous water demands safely. While planning reversible systems, such as Algyő main channel, different needs (excess water drainage, irrigation water supply) must be taken into consideration at the same time, and it is important to strive for harmonising them.

Possibilities of irrigation development

Due to the elevated character of the middle and western part of the catchment the main water resource is the Tisza, which passes on the border of the sand-land; therefore water for irrigation can be transferred to this elevated area only by large engineering investments or by embanked open channels, divided into several sections or by pressurized pipelines. In the case of open, earthen irrigation channel the loss of water due to evaporation and infiltration is very high, while in case of pressurized pipelines the loss is negligible. However the costs of the investments can be higher by an order of magnitude in case of the second option. To the inner area of the elevated sand land, larger amount water can be transported only by complex investments. While implementing these types of projects, complexity must be aimed; the viewpoints of sustainability and economy can succeed in this way. During the development of water controlling system, there should be taken into account the possibilities of constructing several reservoirs, which can store the surplus water in spring time, thus they can decrease the runoff from the area and lessen the load of urban sewage systems.

We should make into some consideration the Danube-Tisza channel, which is a historical but repeatedly revived idea. This investment would modify the whole hydrological regime f the Dunube-Tisza Interfluve. About the hydrological and ecological effects of this project, there is a professional debate.The water supply system can be achieve by the better utilization of the existing system and by connecting the existing seepage and drainage channels into a system. A good example is the Dong-ér main channel reconstruction. These projects can be achieved by lower budget and in shorter time. The water transport capacity of the main channel is high enough to make possible the connection of other water systems, thus the area of the investment could be developed later.

Farther from Tisza, the costs of water supply are high and the available local surface water is not enough for irrigation, therefore the main source of water in this area are the subsurface water resources. The possibilities of use this resource is varying spatially, since besides the demands, the sustainable discharge and recharge time of groundwater should also consider to ensure sustainable agriculture. Using subsurface water is problematic, because delineation of the catchment of the water bodies is difficult, thus the estimation of available water is hardly achievable. Large-scale farming cannot be based on subsurface water resources, this resource can be possibility only for small-scale farming, but using water-saving technology is essential also in this case.

The drinking water output from subsurface water reservoirs is 120 000 m^3/day in the area, based on the statistical data of the settlements. This means 45 million m^3 in a year. Moreover 15 million m^3 in a year is used for industrial purposes. These waters will become mainly waste water after utilization. The generated communal and industrial waste water of 31 million m^3/year could be reused as water source after cleaning. A very small amount of waste water is returned to the ground at present, but mostly these waters are let into drainage channels and finally into the rivers, thus these valuable water resources leave the catchment unused.

One of the most important issues is the preservation of local waters using the morphological potential of the area. The valuable temporal water surplus should be retained in water storage lakes or by systems where infiltration is accelerated. This water could meet the water demand of small-scale farmers. In case of these reservoirs, the location in the catchment is very important, since on the upper sections of the catchment, the available water is less, thus these storage lakes should be constructed on the middle or lower sections of the catchment. Special attention should be given to the utilization of accumulated inland excess water resources, since this phenomenon is a frequent problem in the area.

On the area examined inland water irrigation is a given option, but there are large spatial differences on the basis of inundation maps. However, there are several restriction factors in the extensive use of this water resource. . One problem is the amount of inland excess water, since the amount is limited temporally and spatially, and another limiting factor is the quality, which influence the way of use. Using inland excess water resource could be not only economically advantageous (decreasing protection and damage reduction costs), but it could help to gain better ecological conditions in an area. Considering the entirety of the catchment area, the suitable territory for inland water irrigation is 3282 hectares; but the location of these areas (Fig. 5.7a on page 176) is not favorable, since on the higher elevated areas of the catchment, where the water resources are scarce, this phenomenon is not frequent, thus not enough for supplying larger areas. Therefore in this area water storage in channels should be in focus (without inundation) with applying channel storage and facilitating infiltration, thus on the lower section of the channel the load could be reduced. Moreover water surplus cannot be stored for the next year, because it would have high cost, therefore it would not be economically sustainable due to evaporation loss and the quality of water is worsening with time.

Besides storage possibilities the role of multifunctional reservoirs has to be mentioned. There are other needs than preserving water resources. Fishing and recreation purposes became more important in the neighbourhood of the settlements; it makes the raising awareness possible, however the different purposes require different operations, thus it generates conflicts.

During the development of irrigation farming, the assessment of site conditions and the adaptation influence profitability. In case of areas with favourable site conditions, the expenses show a return in a shorter run, furthermore the crop yield is better. During the planning of irrigation the determination of soil type and the possibility to irrigation are also important, since soil cover is quite heterogeneous in some catchments. Due to the above mentioned reasons, site conditions have to be considered, not only in possiblility, but condition point of view.

Besides the site conditions water needs of the planted plants are also important. The choice on crop types is even more important with the increase of the distance to water resources, since the delivery of water to the field has huge costs due to energy expenses and water loss.

By the water supplement of the drainage system, a maximum 150.000 ha could be irrigated (Fig. 5.7b on page 176). The reality of this number is small, since it would cost a lot of money. During the planning of water supplement the capacity of the system should be determined properly, a proper amount of water has to be available for irrigation; the miscalibration of the capacity can not be a limiting factor for further developments

Economy is highly influenced by the irrigation systems of high water and energy efficiency. Planning of such systems should consider savings and efficiency, thus equipment with less pressure, rain-type, dripping and micro-irrigation systems should be promoted. Thus, areas suitable for irrigation have to be allocated, production system should be defined, and the most proper way of irrigation should be selected. In the point of operation, night irrigation should be promoted to avoid energy peak periods and reduce evaporation loss.

The situation of irrigation on the study area in Vojvodina

In Vojvodina the territory of irrigated areas is only 2.7%, and the proportion of irrigated arable lands is only 2% (Fig. 5.8a on page 179). The reason of this is that the extensive irrigation system of Vojvodina is only partially operating, its maintenance has been neglected in the past decades, and therefore, its larger part is not suitable for irrigation. The volume of irrigation within Vojvodina is well illustrated by the annual amount of water used. The estimate of water used is based upon the size of the irrigated area, the average consumption supported by the Water Master Plan of the Republic of Serbia, and the length of the irrigation period. On this basis the quantity of irrigation water is the highest between the Danube and the Tisza, as well as in the Zrenjanin region to the east of the Tisza. According to agricultural surveys, 45% of water consumers use subsurface, while 40% surface water supplies, which means that the consumption of subsurface and surface waters is similar in quantity. This proportion of consumption of slowly supplemented subsurface water supplies decreases the sustainability in irrigation.

The proportion of irrigated areas in different regions of Vojvodina is similar. The biggest is in West Bačka, where 2.78% of the whole territory is irrigated; in South Bačka, with 2.4%. The smallest proportion of irrigated areas is in Central Banat with 1.64%, but it also has the smallest proportion of arable lands among the regions. The distribution of irrigated crops is also similar in the regions. On irrigated areas mostly (on one-third) fodder-plants are grown (corn and fodder-plants). The areas of vegetables, open-air fruits (strawberry, melon), and sugar beet are also considerable.

Vojvodina has a significant amount of surface water supply owing to the water coming from the Danube, the Tisza and the Sava, which make the areas surrounding the rivers irrigable. In the central parts of Vojvodina, which are further away from rivers, the Danube-Tisa-Danube canal system would make irrigation possible on substantial lands. Vojvodina has significant subsurface water supply (Fig. 5.8a on page 179), but utilising this raises questions of sustainability. On the basis of available water supplies, closeness of irrigation systems, topography, and soil properties, areas suitable for irrigation can be designated (Fig. 5.8b on page 179).

5.3. Possibilities of floodplain and waterflow rehabilitation and revitalisation along a canalized small waterflow

Tímea Kiss, Borbála Sümeghy

Introduction

Natural small waterflows were transformed into deep canals; the surrounding floodplains were protected from the flood, while marshes were drained in the 20th century. As a result of such interventions, the natural fauna and flora decrease in extent or disappear in general (Rohde et al. 2005), the deep canals decrease the groundwater table of the surrounding areas (Völgyesi 2006) and air humidity decreases in parallel with the disappearance of marshes (Somogyi 2000). These factors together lead to the aridification of the area, which can be even more expressed in the study area involved in the project. Therefore, our aim is to study how to restore the original hydro-morphological functions of the drainage canal and that of the irrigation canal in order to solve water retention and groundwater re-supply in the neighbouring areas.

The rehabilitation of the waterflows which had lost their functions or had been converted and that of the floodplains can be performed for several purposes by applying different approaches (Nagy and Novák 2006). The general aim of the interventions is to plan a naturally functioning canal or floodplain that could work in a stable way for a long time (being able to transport sediment and water at sufficient rate). The slightest intervention is *revitalization,* whose aim is to improve the ecological conditions. *Restoration* can be applied in case of more degraded habitats, which aims at bringing the structure and functioning of the habitats and ecosystems of the floodplain and fluvial water back to their state before intervention (National Research Council 1992). During *rehabilitation,* following intervention, the area is turned into a beneficial area; in case of habitats, which had disappeared or still exist but unable to function along water or water banks, the aim is to restore functions and processes to reach a pre-defined target status (Dunster and Dunster 1996, Petty 2004). The goal of *re-naturalization* is to achieve a natural pattern by changing certain morphometric parameters of the waterflow, which may result in the development of a more sustainable ecological system (Petty 2004). *Reclamation* has a goal of improving the biophysical capacity of the ecosystem (National Research Council 1992).

The basis of floodplain rehabilitation

Floodplain rehabilitation comprises the formation of the morphology of a waterflow in a way that it could adapt to its present hydrological circumstances and to bring back/ transform the wetlands into their original, or even better condition. Rehabilitation and formation of wetlands on the floodplain can be carried out by restoring their connection with the river targeting the status before the disturbance (Mitch and Gosselink 2000). During rehabilitation, it is essential to clarify (1) which section of the waterflow is to be restored, (2) what causes the problem there, (3) what the consequence of the problem is, (4) how to resolve the issue, and (5) how to hinder re-occurrence of the same problem in the future. Restoration can usually be regarded as a concise process since waterflows are complex systems, therefore hydro-geographic, water engineering and ecological aspects have to be taken into account, as well.

Various approaches and goals could be set for the restoration and formation of wetlands (Mitch and Gosselin, Rohde et al. 2005). In our opinion the aim could not be to restore the status before intervention, rather, to create an optimal status, because natural systems constantly change and adapt to the environmental conditions due to climate change and significant human activity. These objectives could be set:

1. Preserving present condition. Optimal land use on the related catchment and the zonation of areas along the river may be necessary in order to filter disturbing effects before they reach the waterflow or the floodplain.
2. Making improvement in the relationship between members of the network by means of influencing water and sediment transport. The link between certain fluvial forms and habitats need to be ensured by revitalizing the overflow canals, by connecting floodplain flats and the river, by removing riverbank protection and the breakwater that hinders the sideward development of the canal.
3. (Partial) correction of habitat diversity could be achieved by providing the adequate floodplain and canal forms. This could be achieved if canal forms (such as pocket-fords) are re-created, sediment traps are established, or floodplains are formed in lower areas (which are inundated more often).

It is essential to determine water quality, since ensuring water supply is the crucial aim of rehabilitation. At the same time water quality is not necessarily affected by local factors, so one of the tasks is to optimize the catchment area of smaller waterflows (for example, forestation, optimal land use, buffers, modifying runoff). Besides the morphological reconstruction, ecosystem functions has to be restored into a better condition, thus, invasive species has to be controlled (at least in the first few years of rehabilitation until natural vegetation strengthens). If possible, intervention should be implemented with minimal maintenance, that is, the hydro-morphological and ecological systems of the floodplain should be able to maintain and develop on their own. The system also needs to be planned in a way so as to buffer the (minor) disturbing effects. Natural organic and inorganic systems may return to their original status quickly, so floods, droughts and storms are not able to disrupt their balance in the long run. It is crucial to give enough time to the waterflows and wet habitats to be able to function during planning. It may take years for the canal morphology to adapt to the hydrological boundary conditions: plants become stronger, animals populate the area or soil formation starts.

Practical steps of floodplain and small waterflow reconstruction

Scientific analysis is required prior to and after floodplain rehabilitation, which consists of several steps. In this study the morphological reconstruction, that is, the formation of appropriately functioning canal and floodplain forms, is emphasized. However, similar steps are to be taken using other tools for the reconstruction of certain elements of the ecosystem.

(1) Defining the aim

At first, the long-term goal to be achieved needs to be determined. It could be various according to the rate of rehabilitation (complete reconstruction, rehabilitation or re-naturalization). Other goals could be the restoration of the hydro-morphological balance of the canal, to restore the complexity of natural habitats, to provide habitat for certain species, water retention etc. (Petty 2004). The morphological priorities of rehabilitation are (1) to ensure the connection between the floodplain and the canal, (2) to provide gradual flooding by cutting the floodplain, and (3) to create a stable canal with more natural morphology by the reconstruction of vertical and horizontal parameters of the meanders.

Firstly, for the planning of target condition, it has to be determined what caused the degradation of floodplain/waterflow and its potential function loss. To achieve this, (1) the present hydrological, morphological and ecological conditions of the waterflow need to be mapped, (2) the natural and antropogenic factors, the limiting factor causing the loss of balance also need to be defined (Rosgen 1996, Petty 2004).

(2) Selecting the plan for rehabilitation

After defining the problems, the reasons behind them, and the target condition to be achieved, the most suitable rehabilitation strategy has to be selected. What makes the planning of rehabilitation more complicated is that not all procedures are applicable for all types of river, so firstly, it has to be checked what general techniques of rehabilitation could be applied (see Manual of River Restoration Techniques 2002). However, it has to be noted that there is no standard manual to be followed. Possible methods of intervention are illustrated by examples. The canal could be made winding with pockets and fords there, the canal and the lower, far away areas could be connected with crevasse, by cutting down the floodplain areas along the riverbed it is possible to drain the gradual (and not destructive) weathering waves, wetland with various depths could be established, the levee could be placed more backwards or could be opened etc.

(3) Implementation and assessment of the plan

After the preparatory steps, the plan has to be completed, which involves the preparation and implementation of the plan. After completing the work, the reconstruction has to be assessed on the basis of monitoring measurements from hydrological, morphological and ecological points of view. It also has to be evaluated if the completion of plan helped to solve the problems and achieve the targets and plans (Petty 2004). A monitoring program of 5 years is required and the experience could enhance the efficiency of future reconstruction work (Bernhardt et al. 2005).

Possiblity of floodplain rehabilitation on a study area in Hungary

This floodplain rehabilitation was planned along the session of Száraz-ér running at the eastern border of Csongrád County. The problems arising here are due to the consequences of regulation and flood protection works. By turning the small waterflow into a canal, the course, slope and sediment transport capacity of the river have changed, while the size of floodplain was reduced to the minimum by building levees, and the temporary water inundations disappeared outside the levees. Another reason behind the problem is that Száraz-ér was cut off from the River Maros feeding it, thus the water discharge decreased. Due to this fact no real floods occur nowadays, although, in years with inland excess water inundations, the inland water carried by the canal might overflow into the floodplain areas. The neighbouring areas tend to become arid as the canal was incised to 2.2-2.5 m deep, thus, the low water level typical for the rest of the year had sunk. The floodplain wetlands disappeared and the flora and fauna became less diverse on the former floodplain area which had been cut off from the canal. Saline meadows can be found here, their maintenance could be improved by being flooded temporarily, and the flooded depressions could serve as diverse habitats. On the whole, the above processes resulted in the fragmentation of the ecological corridor along Száraz-ér. Taking into account the environmental changes mentioned above, it is observed that the area in its present state does not function properly either morphologically, or ecologically.

Our aim is (1) to form a meandering canal instead of the straightened canal, whose development could be sustained by the actual reduced water discharge, (2) to reconstruct certain floodplain forms, and (3) to establish floodplain habitats at various water depths.

Geomorphological features of the study area

The straightened bed of Száraz-ér, being transformed into a canal, crosses the study area (Fig. 5.10 on page 187). A narrow flood catchment area was created on both sides of the canal with the help of a 1-1.5 m levee. At some places this levee was incised so that the flood could spread on the former floodplain.

The canal was meandering on the floodplain before building the levee, and inundated it from time to time (Fig. 5.11 on page 187). The width of the floodplain is between 200 m and 600 m. From the north and south, a bank separates it from the high floodplain that is situated 2-3 metres higher and is being used for agricultural cultivation. The surface forms before and after regulation are separated in the low floodplain (Kiss and Sümeghy 2008).

The canal of the former Száraz-ér, which is the lowest elevated part of the study area, belongs to the forms before regulation. The natural canal of Száraz-ér could have been very shallow before canal building, as drillings revealed that the canal bed was at the depth of 50-60 m. At the same time the canal had a width of 50-60 m at the apex of the meander, while it was 30-40 m wide at the straight sections. At some places islands were formed in the widened canal. Rows of point bars with 2-3 parts join the bend. Some point bars remained intact, while the others were fragmented due to salinization following the regulations. 20-30 cm high salt berms cut by rills were formulated from the higher point bars.

Calculation of meander parameters

The target was to plan a meandering canal instead of the actual one. In order to perform the task, the former water discharge and the canal parameters that could be sustained at the present water discharge, had to be determined. Williams (1984) formulae were used for the calculations.

The radius of curvature (30-174 m) and the width (22-60 m) of several former meanders in upstream direction from the study area were measured. On the basis of the mean radius of curvature (89 m), the average water discharge could have been 7.1m^3/s before the regulation, while it could be 15.0 m^3/s based on the mean width (51 m).

Unlike the above mentioned, the average water discharge of Száraz-ér is only 0.6 m^3/s at present as it was cut off from the river Maros during regulation in the 19th century. That explains why it would not be a good idea to let the water overflow into the original large meanders. At the current water discharge, the natural way of meander formation could only realise in a narrower canal meandering more sharply. On the basis of the current water discharge, the sustainable canal bankfull discharge width is 5.1 m only, whereas the average radius of curvature is 12.9 m. It can be concluded that a waterflow with more meanders, meandering at narrower and smaller wave length (on average 81 m) ought to be planned on the study area.

Possible ways of floodplain rehabilitation

The features of the area have to be considered during the formation of a well-functioning waterflow and floodplain. After water regulations a stable but low-diversity flora and fauna develops in the deep canal so work has to be planned with a possible minimal disturbance. It also has to be taken into account that no regular floods can be expected- they occur only in humid years, although the area may be inundated for a long time. Neither intensive meander development, nor floodplain fill-up can be expected. As a result of regulations, the discharge, power and sediment transporting capacity of the water flow decreased. Not even the higher water discharge is able to carry substantial suspended load.

For a successful planning, steps must be built on each other, in this way they establish a chain of feasibility processes.

(1) New canal formation

The first and most important action is to form a new canal. A meandering water flow could be established in the paleo-canal on the basis of using the parameters calculated from its discharge. It may take places here as in this case the deepest points of the region are chained by the new canal and this would require less earthwork. Based on the wave length of the new meander (82 m) and the length of the paleo-canal (2600 m), it can be calculated that altogether 64 meanders could be formed in the previous large meanders. The new canal would meander at the deepest bottom of the paleo-canal with the radius of curvature of 9-16.5 m.

References recommend that the deeper pockets and the shallower fords are to be created in order to maintain the function of the canal (MRRT 2002). It was calculated that the bankfull water depth at the inflexion points / at pockets is 0.7 m, while the maximum depth of the fords could be 1-1.4 m in the meanders, and the canal would be 1-1.5 m wide. The discharge of 0.6

m^3/s could completely fill the new canal up. At higher discharge, even the paleo-canal would be filled (Fig. 5.12 on page 190) The paleo-canal would serve as the bankfull canal during greater floods. Wider but narrower cross-section (eg. 2.0× 0.3 m) was not selected because water could remain cooler in the deep-water canal with better oxygen provision.

During new canal formation, the amount of removed sediment is 1.05 m^3/rm. Since the new canal length would be about 3800 m on the study area, the amount of removed sediment would reach 3990 m^3 for this section. Consequently, the material of the present levee would not have to be used during earthworks. Sufficient sediment originating from the new canal would be available for the diversion of present canal, and at the same site, the remaining sediment could be used to build a lookout tower.

The sediment removed during earthworks could be used to build a sediment plug (Fig. 5.13 on page 191). Based on the cross-section of the canal it can be calculated that the amount of material needed to fill up the sediment plug is 6.8 m^3/rm. As the canal has to be filled up at six points, altogether 240 m of material has to be moved for fill-up. However, much more sediment had been produced (3990 m^3) which should be deposed at another area remembering that the sediment consist of clay and organic materials. Another option which requires less transport is to create a lookout tower out of the deposited material. The visitors could observe the area, its fauna and flora and the objects could be on display (Kiss and Sümeghy 2008).

Much attention should be paid to protect the present-day fauna and flora with earthwork without disturbing them as little as possible. The surface grass cover has to be removed so that they could be placed back to the area of canal fill-ups and the lookout tower. This would reduce the rate of degradation of the disturbed area. The earthworks should expose the area to slighter trod damage.

(2) Water level control

The water level has to be raised because the bottom of the new canal could be 1.3 m above the bottom of the canal now (Fig. 5.14 on page 192). Száraz-ér should be dammed at the lowland end of the section. This could be performed in many ways. Soft-engineering would work best in this case. As the water has small discharge and destructive floods are not expected, the dam could be created from billets and it would control the water (Fig. 5.14 on page 192).

The height of dam would match the water level of the new canal. The new canal would have bankfull discharge the whole year, and in case of higher water levels, water could spread over the paleo-canal, during floods it would cover the floodplain. Damming would have impact on the whole study area. It would elevate the water level of the upland, canaled sections of the river. During flood, the lowland floodplain would be inundated without threat to the upper, 2-3 m higher cultivated areas.

(3) Connecting the floodplain and the waterflow, creating new forms, wetlands and lookout tower

It is an important action to connect the floodplain and the waterflow in order to create wetlands. Száraz-ér is not exposed to frequent floods, therefore completion of this action is the most difficult. It is complicated to provide regular inundations- except for humid years with excess water. The temporary flooding on wetland patches and their water re-supply could be achieved with the help of crevasses. The features of the future wetlands can change as we can form wetlands (1) with higher water cover; their water re-supply has to be resolved for longer period exposed to excess water, (2) with shallow temporal water cover that could dry out for a long time.

The wetland habitats with higher water cover could be transformed from the straightened and dammed sections of the new canal. It can be regarded important, since the species could start spreading on the new floodplain area from this territory. A constant water depth of 2,0-2,2 m would be available in these deep-water lakes. The water re-supply of the lakes could be provided by crevasses (Fig. 5.15 on page 193). They would drain the fresh water from the new canal towards the canal.

The exact location of wetland habitats with shallow water cover was determined with the help of precise relief examination and satellite map. Water can be drained to shallow (maximum of 40-50 cm water cover), temporarily drying habitat patches by deepening the rills, thus this would allow the water to cover the area periodically. The settlement of new species is also expected from the deep-water wetland habitats (Kiss and Sümeghy 2008).

In order to make the flooding last for a longer time, the slope of crevasses should have the direction of the wetlands (by 1-2°). This way it could prevent the water from flowing back into the canal and the drainage of the water of wetland habitats could be avoided. Crevasses would open towards the wetland habitats from an outer arch, which could assist easier water flow. Crevasse formation would require minimal earthworks – extremely narrow forms can be found here and what is more, in case of deep-water habitats, water would be directed through the earth plug clogging the present canal. Crevasses would be positioned at the same level as the floor of the old canal and the water level of the new canal. A discharge of approx. 0.6 m^3/s would already supply the deep-water lakes.

The remaining sediment (3786 m^3) could be utilized to build a lookout tower next to the study area. During deposition, a hill with the diameter of 17.4 m and the height of 4 m could be formed. A wooden lookout tower could be placed on top of the hill with view of the whole area. The lookout tower would work as a station of a trail around the area, whose aim could be to enhance the approval of such project by the society.

5.4. Optimal land use to increase adapting capacity

Péter Szilassi, Viktória Blanka, Zsuzsanna Ladányi, Popović Ljiljana, Popov Srđan

Introduction

In the study area it is necessary to develop regional, county and settlement level regional development policies and land use structure, which has the lowest possible risk of agricultural damage due to climate and weather extremes. It is important to prepare recommendations and land use change options in the land use plan of settlements in the study area that helps adaptation to the expected future extremes. In accordance with these the objectives of the research can be grouped into two main topics. One of the goals is the analysis of agricultural drought as a functional land use conflict. Another important goal is to propose regional-scale land use pattern, which has the lowest possible risk of agricultural damage due to climate and weather extremes.

Relationship between soil properties and land cover change on agricultural land between 2000 and 2006

The chance of the appearance of agricultural drought is significantly affected by the soil and hydrological features of a given area, apart from climatic conditions. Therefore, we have to investigate properties of the soils to analyse the consequences of drought. We selected a surface cover change type for the entire territory of Hungary, in which physical geographical factors can also play role. This change is the transformation of arable lands (211) to abandoned lands meaning meadows, pastures (CLC code 231), or shrub-bush areas (324), forests (311, 312, 313), grasslands (321). The main question was which pedological factors play a role in the abandonment of agricultural lands. In addition, we investigated if the role of drought can be detected in the recent changes in land use. Furthermore, if it is a justifiable hypothesis that the areas most affected by drought are more prevalent among the abandoned arable lands (e.g. they transformed into meadows, pastures, fallows, scrubland or forests) than other areas?

To analyse the relationship between soil parameters and surface cover change between 2000 and 2006 CLC change map was compared to AGROTOPO digital soil map, which contains information on nine soil attributes (soil type and subtype, parent material, soil texture, clay mineral contents, soil water household, soil pH and carbonate content, organic matter content, thickness of fertile topsoil and soil productivity). The characteristic soil properties were examined in areas of land cover change between 2000 and 2006, and the percentage of each soil property categories in the transformed areas were calculated (e.g. in the case of soil texture, sand, loam, clay, etc.). We tested whether the different soil properties may play a role in the abandonment of arable land.

Based on the results there is a correlation between pedological components, which are important for drought sensitivity and influence soil water household, and recent land cover changes. Among the sub-categories of soil properties sand soil texture and poor water holding capacity show a significant positive difference in the proportion of land cover change in these areas and arable land having transformed into abandoned land. The arable land - abandoned land transformation occurred in a higher proportion on drought-sensitive soils with bad soil water household (Table 5.1 on page 197) compared to other surface cover change. The lowest proportion of arable land-abandoned land transformation occurred in loamy soils less sensitive to drought, which have good water retention properties.

Crop production on arable land is of outstanding importance in economy and land cover of Vojvodina and the South Hungarian Plain, as well. Since the occurrence of agricultural drought may become more frequent, the key issue is the elaboration of a land use pattern that is the least vulnerable to the effects of drought, in which case the least yield loss is expected.

A significant part of the study area has chernozem soils with good, or excellent yield potential, and high humus content. On these areas arable crop production has to be preferred in the future, too, where the choice of the appropriate plants and adaptive water management may mean adaptation instead of changing the land use type.

For example, one solution can be the increasing ratio of drought-tolerant species. In areas where corn, sensitive to drought (heat, water supply), shows high yield variation, it is advisable to reduce the corn-growing area and increase the area of winter wheat and other less drought-sensitive cereals instead. A similar adaptation strategy was developed by Chinese experts for some areas of China where cereal cultivation is no longer profitable for local farmers due to aridification (Yongdeng et al. 2014) (Fig. 5.16 on page 198). It would be important to use shelter belts to protect against wind erosion. In addition, smaller reservoirs for water retention for irrigation in the drainage channel network can help in these areas to stabilize crop yields.

In our research we showed that the most significant drought hazard occurs in case of sandy soils with bad water retention capacity. The wind erosion hazard is also higher in these areas (Lóki and Négyesi 2009, Mezősi et al. 2013). As we have seen, the arable land-abandoned land use change was also of the highest proportion in the period of 2000-2006 in these areas. The farmers recognized that crop production was no longer economical. It is likely that yield loss in drought years played a significant role in the background of land abandonment (arable land to grassland and forest). Land use less vulnerable to drought compared to crop production should be promoted. In sand dune areas forests or grassland/pasture would be optimal instead of arable lands. Humic sandy soils have higher yield potential to a certain extent than blown sand, but their water household properties are similarly unfavourable for crop production (Fig. 5.17 on page 200). Substantial parts of these areas are currently being intensively irrigated because of vegetable production. Since these soils are favourable for vegetable production, in areas where water supply can be solved, adaptation involves of the application of adaptive water management and water-efficient technologies instead of land use change. Where water supply is problematic, forestation, or pasture can be recommended.

In Vojvodina, soil erosion by wind highly influences arable lands and it leads to the degradation of fertile lands due to land use pattern (large extent of connecting fields of arable lands and a low percent of forests). Land-use change in future requires forestation and designing shelterbelts on agricultural land. For the sustainable management of protected areas, it is necessary to establish eco-corridors, thus, an ecological network in this arable land dominated landscape.

The projected future climate will also be likely to influence the structure of agricultural production. The projected climate can have a positive effect on the majority of winter crops, while it can have a negative effect on summer crops resulting in reduced crop yield. The possible measures of adaptation in the sector of agricultural production can be classified as short-term, mid-term and long-term measures. The agricultural producers themselves can implement short-term measures, which do not require great investment and can be implemented immediately. Short-term measures are primarily related to:

- decrease of summer crops and increase of the winter ones
- improvement of soil structure with appropriate agro-techniques to increase water capacity of soil
- adjustment of timing of works to the changing weather conditions

Mid-term measures of adaptation require a longer implementation period. They are primarily related to improving soil fertility:

- optimization of water and air regime of soil
- improvement of nutrient supply and chemical attributes (e.g. pH) to increase potential fertility of soil
- adopting dynamic monitoring and controlling system in agricultural production to regulate soil fertility and optimal growing conditions

Long-term measures are the most effective adaptation measures, but they require significant investment and understanding of both national and local governments. The most important long-term adaptation measures are certain:

- breeding new species with higher level of drought tolerance
- investing in research and development of new water efficient irrigation systems and infrastructure
- developing a system for drought early warning and other elements

Further strategic goals of sustainable land use in Serbia are the harmonization of legislation acts concerning the use and protection of land with EU legislation; preventing further loss of land and the preservation and improvement of its quality, protection from degradation, change of purpose and cultivation of agricultural land.

Finally, it is necessary to emphasize the significance of the monitoring and early warning systems of droughts in planning short and longer term adaptation measures and justifying the efficiency of these measures. Development of drought early warning systems is difficult due to the complexity of the phenomenon and it requires a complex approach. Therefore, these systems are less developed on global and also on regional level than warning of some other natural hazards (e.g. flood). The goal of spatial and temporal monitoring of droughts is spotting dry periods before consequences become visible and damaging for agriculture.

5.5 Future policy making

Viktória Blanka, Zsuzsanna Ladányi, Károly Fiala, Dragan Dolinaj, János Rakonczai, Vladimir Crnojevic, Đorđe Ćosić

Introduction

Climate change is a major conceptual challenge to water managers, water resource users (e.g., in agriculture) as well as to policymakers in general, since the changing climatic and hydrological conditions generate new and increasing environmental and consequently social hazards in the future. This chapter discusses issues, strategies, and approaches to sustainable water management and development in the Hungarian-Serbian Cross-border region. It focuses on principles of drought policy and harmonization practices in cross-border situation; relevant regulations in the two countries and the guiding EU principles; furthermore it outlines some recommendations in planning water and natural area management and some spatial planning issues.

Aims of drought policy

Planning sustainable development requires the integration of economic, social, and environmental considerations as a key to maintaining basic living standards and protecting ecosystems. Policies and strategies provide the framework and guidance to support the implementation of best management practices and suitable interventions. Policies related to disaster mitigation, preparedness, recovery and resilience must increasingly consider aspects of climate change and human and natural biological processes of adaptation (Whitney 2013). Between policies and strategies special emphasis should be given to drought policy in the Hungarian-Serbian Cross-border region, since drought is one of the most severe environmental hazards in this region.

In general, a national drought policy should consider the following principles: (1) Favour preparedness over insurance, insurance over relief and incentives over regulation; (2) Set research priorities based on the potential of the research results to reduce drought impacts; (3) Support the cooperation and collaboration of governmental institutions and services with nonfederal entities. The key elements of national drought policy incorporate planning, implementation of plans and proactive mitigation measures, risk management, resource stewardship, environmental considerations and public education. The drought policy should also improve collaboration among scientists and managers to enhance the effectiveness of observation networks, monitoring, prediction, information delivery and applied research and to foster public understanding of and preparedness for drought (Whitney 2013).

Without a coordinated, national drought policy that includes effective monitoring and early warning systems to deliver timely information to decision makers, effective impact assessment procedures, pro-active risk management measures, preparedness plans aimed at increasing the coping capacity, and effective emergency response programmes directed at reducing the impacts of drought, nations will continue to respond to drought in a reactive, crisis management mode (Sivakumar et al. 2014).

To reduce the impacts of drought there is an urgent need to focus attention on the identification of the most vulnerable sectors, population groups, or regions. The risk associated with drought (and other natural hazards) is a reflection of both a region's exposure to drought conditions and its vulnerability. Exposure is defined by the frequency and severity of historical drought occurrences and current trends. Vulnerability is defined by a long series of social factors, including population growth and migration patterns, land use changes, technology, urbanization, environmental degradation, water use trends, government policies, and environmental awareness of the population.

Since climate change has significant effect on protected areas in Europe, it is a growing issue in the scientific community. Planning appropriate adaptation measures and sustainable management plans require better information at the regional and local planning and management levels (Rannow et al. 2010; Lorz et al. 2010).

Transboundary planning

Transboundary environmental issues, such as drought, water resources, require cross-border working. The cross-border dimension of managing water resources and shared river basins brings up interesting challenges for both jurisdictions while, at the same time, generating opportunities for collaborative working in the preparation and implementation of River Basin Management Plans (RBMPs) under the European Union Water Framework Directive (WFD).

The collaborative working in cross-border areas needs multidisciplinary approach, since the economic and demographic changes in the border region also have a substantial impact on the natural, social, and built environments. Cross-border planning is defined as an institution-building process to achieve mutually beneficial outcomes. Its primary emphasis is on the facilitation of collective action with regards to the shared natural, built, and human environments constrained by territorial politics and boundaries of states (Pena 2005).

To construct comparative policy research across countries it is necessary to ensure an extensive knowledge and good basis datasets for comparison. Research have to focus on the search for a complete package of elements that can be transferred to another situation; examination and adaptation of specific elements of the policy process and program, e.g. aspects of a monitoring program, participatory process or communication strategy. Comparison is important in cross-border policy research, since these analyses can reveal the existing similarities (which can provide a basis for the following steps of planning) and discrepancies (needing harmonization). The comparison can be achieved on the basis of political/legal system, administrative structures/processes, biophysical character, substantive issues, socio-economic similarities, policy instruments used or proposed, use of information (and uncertainty) in policy system etc. (Dovers 2005)

The EU is also paying great attention to climate change and its connected environmental hazards, such as drought. Several Community level Policies and Directives provide the framework of planning sustainable agriculture, water management and planning natural areas. These Policies and Directives may help harmonise cross-border policies. The aim of the EU's Common Agricultural Policy is to live up to the new challenges facing European agriculture. Such challenges are, for example, the more sustainable use of natural resources, climate change, the intense competition of globalised markets, as well as the demand to maintain booming rural territories everywhere in the EU. The targets of the Common Agricultural Policy include economic aims (to ensure food safety through viable agricultural production, to improve competitiveness and value distribution in the food chain); environmental aims (the sustainable use of natural resources and the fight against climate change); and territorial aims (to ensure the economic and social dynamism of rural areas).

The EU Water Framework Directive (2000/60/EC) addressed the main overall objective to ensure access to good quality water in sufficient quantity for all Europeans, and to ensure the good status of all water bodies across Europe. Management by river basin - the natural geographical and hydrological unit - instead of according to administrative or political boundaries is aimed and transboundary level has to be also considered. Policies and actions are set up in order to prevent and to mitigate water scarcity and drought situations, with the priority to move towards a water-efficient and water-saving economy. In 2007 impact assessment has been prepared by the EU Commission services to support the Communication on Water Scarcity and Droughts. Seven policy options were identified for tackling water scarcity and drought issues: (1) Putting the right price tag on water, (2) Allocating water and water-related funding more efficiently, (3) Improving drought risk management, (4) Considering additional water supply infrastructures, (5) Fostering water efficient technologies and practices, (6) Fostering the emergence of a water-saving culture in Europe, (7) Improve knowledge and data collection. The Commission prepares annual Follow-up Reports that assess the implementation of the policy options throughout the EU.

The EU Strategy for the Danube Region is a macro-regional strategy to address common challenges, to create synergies and coordination between existing policies and initiatives taking place across the Danube Region. The strategy addresses a wide range of issues according to 11 priority areas (Mobility, Energy, Culture and Tourism, Water Quality, Environmental Risks, Biodiversity, landscapes, quality of air and soils, Knowledge Society, Competitiveness, Institutional capacity and cooperation, Security).

Current drought management practices are largely based on crisis management. These practices are reactive and, therefore, only treat the symptoms (impacts) of drought rather than the underlying causes for the vulnerabilities associated with impacts (Wilhite et al. 2014). In recent years the importance of drought management, mitigation measures and long-term prevention programmes are started to recognize in policy making worldwide and also in both Hungary and Serbia. New policies are focusing on preparedness, rehabilitation, prevention and planning. Current drought management strategies are attempting to treat drought as a potentially serious disaster, aimed at mitigation and prevention.

The legislation of all water related issues in the Republic of Serbia is determined by the Water law (7.5.2010). The Water law defines the water management methods in the Republic of Serbia. The basic documents in the group of planning acts regarding water management are: Water Management Strategy of Republic of Serbia, Water Management Plan, Annual program of water management and plans that regulate the protection of harmful water effect. The document of highest hierarchy (umbrella indenture) is the Water Management Strategy for the territory of the Republic of Serbia. This strategic plan defines long-term trends and directions of water management. In order to advanced the applicability of this document it is necessary to insert new sections in which risk of extreme water conditions could be estimated such as floods and/or drought. Despite all the good points, the Water law should be amended, and the individual low article should be changed in order to be more complete, applicable, in line with the actual needs and possess greater impact on the safeness of water resources management as a commitment for future generations.

In Hungary regulation is determined by the Law on Water Management (1995/LVII.) and the Law on Environment Protection (1995/LIII). In recent years several plans and strategies have been prepared regarding water management and sustainable development. The Hungarian Water Catchment Management Plan (2009) summarises the differences in good ecological, water quality and quantity conditions of running water, still water and underground water; as well as the necessary acts to reach the aims, as a result of an extensive planning process. The plan separately focuses on the effects of global warming. In 2013 Hungary prepared its National Water Strategy, which aims at creating water management for the optimal use of water sources, that is, to create a balance between social needs and the protection of water as natural value. This strategy is the basis of future water, irrigation development and drought management policies. The National Climate Change Strategy 2008-2025 and the National Sustainable Development Framework 2012-2024 also promote the reduction of the effects of climate change and adaptation. Both documents emphasise the dangers of drought and inland water on the Great Plains.

Complex agricultural and water management proposals of the area

Because of the complex nature of the area problems and actions have to be investigated from different aspects. The perspectives of agriculture, environmental protection, landscape development and society differ, but the links between them is water, without which the area's sustainable development cannot be implemented, especially due to the adverse effects of climate change, which are the greatest challenge. Reducing the adverse effects in the blown sand ridge area, developing the area and the landscape, improving the population-retaining capacity, speeding up the change of the agricultural structure in line with altering natural factors, improving water sources, conserving and restoring natural values, and protecting the landscape and its structure are all equally important and prioritised goals. While reaching these goals one must aim at the sustainable use of renewable, but vulnerable water sources.

Agricultural and Rural Development and land use

- Designing and building infrastructure of irrigation, optimising farm size
- Planning plot structure and crop species in accordance with site conditions
- Upgrading production and processing technology in vegetable and fruit growing, and animal husbandry
- High priority subsidies to agriculture and animal husbandry
- The development of organic farming
- Increasing responsibility of National Parks (meadow irrigation)
- the use agricultural and forestry products in order to gain energy; energy plantations on areas inundated by excess water; reuse of treated water
- Utilising biomass and creating its background industry
- co-operations in agricultural and food industry developments in farming areas
- Complex development of small farming
- Agro-technological and product development
- Creating and developing a network of cooperating groups
- Promoting local products on markets
- Development of food-processing industry
- Creating land use according to environmental features and their changes, in accordance with development approaches and local needs
- Settling ownership issues, encouraging development tendencies
- arable lands should be changed to pasture on inundated areas and reservoirs
- conversion of arable land to economic forests
- Changing production structure on arable lands, choosing appropriate crops
- land use changes aiming nature conservation on protected areas
- land use conversions in protected areas in case of shallow water reservoirs

Drought management on natural areas

Mitigation and adaptation become more crucial beyond the protection of rare and valuable vegetation complexes to prevent biodiversity loss and degradation of the habitats. The result of this research can support the development of complex adaptation plans by providing information about the different sensitivity and possible future threats of the natural areas. Research experiences should be continuously reassessed and adjusted as new information becomes available. Management has to focus on active intervention to increase adaptive capacity, such as water control and ongoing monitoring is essential (Hansen and Biringer 2003). Beside field monitoring GIS based large scale environmental assessment (e.g. applying indicator approach) can highly contribute to the knowledge of the underlying processes. Local management, however, requires further investigations on local conditions, since they can overwrite the large-scale sensitivity. Natural systems adapt to changing climate, but preservation will be more effective if planning is proactive rather than reactive. Early actions are important to build resilience and enable ecosystems to adapt to climate change (Little et al. 2009).

In order to reduce the adverse effects of climate change, four potential adaptation strategies could be suitable: (1) climate change oriented water management, (2) integrated research, (3) need for better cooperation and (4) a more dynamical approach in nature conservation practice.

(1) The most practical approach is the development of a climate change oriented water management. This task is well suited to the national and European strategies on water management. Due to the mentioned increasing hazards, the availability of water resources becomes the greatest challenge in this landscape. Thus, the retention of precipitation and effluent waters is a priority task of the management. Furthermore, the efficient use of surface water resources and also the groundwater resources should be promoted and regulated by adapted local solutions. A site and problem specific adaptive environmental management on arable lands should be addressed.

(2) Multidisciplinary research on the consequences of climate change and the suitable adaptation measures are of high importance. They require a system-approach including the investigation on interdependencies and dynamics of changing factors that has been often lacking despite of the specialized research in certain research fields and sectors (e.g. agricultural production, water production, nature conservation, landscape planning, recreation planning, climate modelling).

(3) The cooperation between governance, research and civil sector should be strengthened to improve the data flow towards the research and backwards to effectively support the realization of water management issues in practice.

(4) The most difficult management issue is seen in the changing role of nature conservation, since climate change affects the landscapes so intensive and strongly that protected areas become threatened. Because of the drying climate wetland habitats will probably be reduced in extent. If wetlands become unsustainable despite of the management practices, the causes of conservation can disappear. Legislation should also consider these factors. Dry steppe vegetation can be endangered by the decreasing vegetation cover due to overgrazing and treading that contributes to wind erosion and activation of sand movement. Conservation management should especially focus on these habitats on the northern part of the Kiskunság where the most increasing drought is expected in the future. A more dynamical approach is necessary to face the changes, which means even different or modified multifunctional land use as solution for the multilayered effects of CC on the nature conservation practice in the landscapes. It also requires a professional research background, furthermore the cooperation of research and practice.

Sustainable water management planning

In order to reach sustainable water management, strengthened harmonisation of general regional development, agriculture and water management are needed, since there are mutual impacts between these branches. The parallel development of these areas makes the achievement of common goals more difficult. It is important for the development units to be well-defined (natural - catchment, in public administration – district), since only this way the appropriate level of coordination can be ensured.

By the implementation of a thoroughly considered and defined strategy, crop safety and quality can considerably be improved, that increases the export share. Considering international processes, the improvement of agricultural standards and the strengthening of farming are justified. Without the harmonised development of different sectors and the appropriate allocation of financial sources, the effects of climate change cannot be reduced – the effects of this process result in unpredictable consequences.

Water management (existing and new water resources)

- outlining the conditions for local reservoirs to preserve local water resources without artificial establishments
- outlining the conditions for water reservoirs preserving local water resources and suitable for water recharge with minor interventions and reconstruction works on water supply systems
- Building storing facilities for draining channels and the surrounding low-elevated areas by reconstruction and land use planning
- setting up and operating a water retention and water recharge management system, revising working order of water facilities, water management on the sand-land
- possibilities for the use of inland water for irrigation
- Utilising local, treated sewage for groundwater recharge (Kecskemét, Kiskunfélegyháza, Kiskunhalas, etc.), further investigation of the developments
- Developing local rainwater management, utilising the resources without damages
- Formation of the water supply system of the Dong-ér
- Intensify water recharge possibilities (economy study on the restoration of the Tiszaalpár-Nyárszentlőrinc irrigation system)
- Establishing water recharge, connecting existing systems, developing local water management facilities
- Implementing complex, regional interventions
- Encouraging water management research, adopting new methods and technologies especially regarding rainwater management, the quality of inland water and the reuse of treated water
- use of renewable energy in case of water recharge and water management systems
- creating a new water management concept for the sandland

From an agricultural point of view drought management should have priority, since this activity helps farmers prepare, moderate the effects, and, thus, reduce damages. The reduction of risk in production depends on timely agro-technological interventions, which can be better planned if farmers are regularly informed. Thus, Drought Management Centre is necessary which is able to supply and coordinate not only predictions but professional knowledge in the field.

The most important issues can be summarised in four points:

1. maximal use of dry farming
2. retaining and storing water resources
3. reusing treated waste water
4. groundwater recharge from external sources.

Social issues

An important problem both in the Autonomous Province of Vojvodina and South Hungary is the unequal economic development of some regions. The unequal economic development is resulted in some social problems, e.g. unemployment, lower living standard, higher exposition to environmental hazards and eventually depopulation (migration from underdeveloped rural areas to urban areas). Possible solution of the problem can be the application of decentralization and polycentrism. In the future, it will be necessary to ensure the growth of smaller gravity centres in underdeveloped regions and thus prevent unequal distribution of population within the region. Tendency of high migrations to developed urban centres leads to demographic problems in rural settlements. Due to this trend, it will be necessary to improve living conditions in smaller villages by supporting infrastructural development and sustainable agricultural, industrial and economic growth. The smaller towns in the rural areas can become the motors of development and provide a centre around which smaller municipalities can group. This cooperation can support the development of both the town and the surrounding villages.

While setting up and implementing a long-term strategy, it is important to improve the population maintaining capacity of the region. In rural regions of the Sandland the protection, improvement and utilisation of natural resources are important for the appropriate circumstances and living standards of inhabitants.